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ABSTRACT

A number of recent reports have called for increased teaching of "problem solving" and "critical thinking," particularly at the elementary level. This paper provides descriptive and evaluative data on a 9-month inservice program in mathematics for 89 elementary school teachers and 6 elementary school principals from 22 different schools. The primary delivery system for the project was six 4-hour workshops by nationally known experts in elementary mathematics education. Topics for the workshops included cooperative learning, teaching problem solving, use of manipulatives, teaching basic skills, and teaching estimation skills. There was extensive interaction and follow-up with the 24 teachers at one elementary school while follow-up at other schools was limited. In addition to documenting the effectiveness of the program, this report is intended as a "how to" guide for school personnel interested in carrying out a similar inservice workshop series. Major sections included are: (1) "Background"; (2) "Need for the Project"; (3) "Overview of the Project"; (4) "Project Objectives"; (5) "Project Activities"; (6) "Project Evaluation"; and (7) "Budget Summary." Appendices include: "Description of the National Science Foundation Project Currently Under Way at the Mathematics Education Development Center"; "Workshop Series Brochure"; and "Evaluation Instruments." (Author/YP)

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MATHEMATICS FOR THE 21ST CENTURY:

PREPARING ELEMENTARY TEACHERS

Final Report to the Indiana Department of Education

October 1, 1989

Prepared by

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MATHEMATICS FOR THE 21ST CENTURY: PREPARING ELEMENTARY TEACHERS

Abstract

A number of recent reports, including the *Indiana Curriculum Proficiency Guide*, have called for increased teaching of "problem solving" and "critical thinking," particularly at the elementary level. The project described in this report provided inservice training for 89 elementary school teachers and 6 elementary school principals from 22 different schools (representing 5 school corporations and 3 private schools). The primary delivery system for the project was six four-hour workshops by nationally known experts in elementary mathematics education. Topics for the workshops included cooperative learning, teaching problem solving, use of manipulatives, teaching basic skills, and teaching estimation skills. There was extensive interaction and follow-up with the 24 teachers at one elementary school (Dyer) while follow-up at other schools was limited. In this report, the project is fully described and evaluation data from both teachers and principals are presented. ***In addition to being a final report of the project, this document is intended to be a "how to" guide for school corporation personnel interested in carrying out a similar inservice workshop series.***

Background

It has become a popular pastime in recent years to criticize the teaching that takes place in our nation's schools. Although there is little doubt that the quality of teaching as a whole is in need of improvement, some of the criticism has been little more than alarmist rhetoric, and much of it has pointed out deficiencies and inadequacies without offering carefully conceptualized solutions. In particular, little attention has been given to the importance of the continuous professional development of practicing teachers. It is our view that in order for the quality of teaching to improve significantly, carefully planned and structured inservice programs must be offered for teachers at all levels and in all content areas. The project described in this report was restricted to the teaching of mathematics in the elementary school. Before describing the project, we comment on the need for providing regular and systematic inservice teacher education in elementary mathematics.

Need for the Project

Two reasons can be given for the importance of this project. The first reason is based on the ever-changing nature of school mathematics, and the second reason stems from the importance of having practicing teachers become more vitally involved in the preparation of individuals who wish to enter their profession. These reasons are discussed in the paragraphs that follow.

The Changing Nature of School Mathematics

If "back to basics" was the catch phrase of school mathematics during the 1970s, it has been replaced in the last five years by terms such as "problem solving" and "critical thinking," and there is reason to expect that this interest in "higher order thinking processes" will continue into the next century. Indeed, in recent years problem solving has been the most written and talked about aspect of the mathematics curriculum. Problem solving was clearly in the minds of the writers of the mathematics portions of the *Indiana Curriculum Proficiency Guides*. Several of the kindergarten/primary level and of the upper elementary level proficiency statements deal specifically with problem solving. Most of the others include indicators which are higher order in nature. For example, a sample indicator of the proficiency concerning developing a positive attitude toward mathematics states that "Students will recognize mathematics as more than computational skill." In other words, school students who have not acquired problem-solving and critical thinking skills have not mastered the content of elementary school mathematics.

In general, the dialogue about problem solving and the efforts to develop curricula and materials for students and teachers have been worthwhile. Furthermore, there are signs that students preparing to become teachers in elementary schools will be reasonably well equipped to

make problem solving a more prominent part of their instruction than has been true in the past. However, it is unlikely that elementary teachers who completed their teacher education programs more than a few years ago (these teachers constitute the majority) have adopted the perspective necessary to teach mathematics in a way that is consistent with the extensive and fundamental changes that are being recommended for the curriculum. (For an illustration of a thoughtful, comprehensive discussion of recommendations for changes in the mathematics curriculum see the *Curriculum and Evaluation Standards for School Mathematics* of the National Council of Teachers of Mathematics, 1989.)

As central as problem solving is to contemporary conceptualizations of how elementary mathematics should be taught, it is but one of several new emphases. For example, other topics receiving considerable attention in calls for curricular revision include estimation, mental arithmetic, manipulative materials, number sense and mathematical thinking. Although in the past these topics were being discussed by a few forward looking individuals, only now have they been widely accepted as themes for mathematics programs of the future. These topics are all contained in the *Indiana Curriculum Proficiency Guides*, yet are not often taught in Indiana elementary schools. (See the final report of the Indiana Department of Education funded study *Current Teaching Practices in Science and Mathematics in Indiana Elementary Schools* by Peter Kloosterman and Harold Harty, ERIC document number ED 285 772). If our teachers are to be expected to implement programs that are vastly different in focus and intent from what they have become accustomed to, they must be given guidance and assistance in how to do so.

The point of the preceding paragraphs is that school mathematics, like all other content areas, is a dynamic and growing discipline. Teachers must be flexible enough to adapt to changes in ways that are best suited to the needs of their students, and it is essential that they be given opportunities to develop such flexibility. The project described in this report was just such an opportunity.

Preparing Teacher Mentors

Appendix A of this report is a description of a teacher preparation project sponsored by the National Science Foundation (NSF) in which the Indiana University Mathematics Education Development Center (MEDC) is currently involved. Although the NSF project is concerned primarily with preservice teacher education, it also involves 24 experienced teachers at one elementary school (Dyer Elementary School) in the Monroe County Community School Corporation. As the activities of the teacher preparation project have been undertaken, it has become increasingly evident that the likelihood of their success is dependent upon the support and expertise of the Dyer teachers. There is no question but that prospective teachers are strongly influenced by the behaviors and values demonstrated by practicing teachers. To the would-be teacher the classroom teacher is the person who really knows what teaching is about because she's

doing it every day. Ideally this is how it should be -- practitioners serving as mentors for novices. However, in order for such a relationship to flourish the mentor must keep abreast of the latest developments in teaching and learning and, most importantly, must be able to transfer to her or his protégé a spirit of willingness to change and to grow. As classroom teachers continue to assume more and more responsibility for the training of new teachers, it is crucial that they be properly prepared to do so. Thus, another purpose of the project described in this report was to work extensively with the Dyer teachers to enable them to prepare innovative instructional materials, use alternative classroom organization strategies, and otherwise further develop their abilities as flexible, up-to-date professionals who will be better able to provide the sort of guidance prospective teachers need.

Overview of the Project

The ultimate goal of this project was to improve mathematics teaching in grades K-6. The primary emphasis was on inservice training of teachers and administrators in the Monroe County Community School Corporation (MCCSC) and in additional public and private schools both within and outside of Monroe County. The primary delivery system for the project was six four -hour workshops by nationally known experts in elementary mathematics education. The workshops were scheduled throughout the 1988-89 school year. Eighty-nine teachers and 6 principals representing 22 elementary schools participated in one or more of the sessions. There was extensive interaction and follow-up with the 24 teachers at one elementary school (Dyer). Follow-up at other schools was limited. Evaluation of the project, described later in this report, focused both on the quality of the workshop series and on the effectiveness of the workshops for those teachers and principals who did not receive extensive follow-up.

Project Objectives

The objectives of this project are reprinted here as they appeared in the original project proposal. They are of three different but related types: objectives related to teachers who participated in the project, objectives related to administrators who participated in the project, and objectives related to teachers and administrators throughout the state who did not participate in the project.

Objectives Related to Teachers Participating in the Project

Public and non-public school teachers who participate in the project will:

T.1 be able to explain how the elementary school mathematics curriculum must change to meet the needs of children who will be leaving school in the twenty-first century.

T.2 increase the quantity and quality of mathematical problem solving they teach as suggested in the *Indiana Curriculum Proficiency Guide*.

T.3 increase the extent to which they teach mathematics with an inquiry orientation.

T.4 increase the extent to which they use manipulatives to teach mathematical concepts as outlined in the *Indiana Curriculum Proficiency Guide*.

T.5 be able to organize their classrooms for cooperative as well as individual mathematical problem solving.

T.6 teach computational skills noted in the *Indiana Curriculum Proficiency Guide* more efficiently than they now can.

T.7 teach estimation and mental computation as noted in the *Indiana Curriculum Proficiency Guide* more efficiently.

Objectives Related to Administrators Participating in the Project

Public and non-public school administrators who participate in the proposed program will:

A.1 be able to explain how the elementary school mathematics curriculum must change to meet the needs of children who will be leaving school in the twenty-first century.

A.2 support teachers in their attempts to increase the quantity and quality of mathematical problem solving taught.

A.3 support teachers in their attempts to increase the extent to which they teach mathematics with an inquiry orientation inquiry.

A.4 support teachers in their attempts to increase the extent to which they use manipulatives to teach mathematical concepts

A.5 support teachers in their attempts to organize their classrooms for cooperative as well as individual mathematical problem solving.

A.6 support teachers who use improved methods of teaching computational skills.

A.7 support teachers' attempts to teach estimation and mental computation.

Objectives Related to Teachers and Administrators throughout the State

Teachers and school officials from throughout the State of Indiana will:

S.1 have a model to follow when trying to develop a mathematics inservice program for large numbers of elementary school personnel.

S.2 be able to gauge the potential effectiveness of using national experts for inservice on teaching elementary school mathematics.

Project Activities

Keynote Sessions

Six large-group keynote sessions on teaching mathematics were presented. The sessions were designed with the expectation that participants would attend all six, although it was clear that scheduling conflicts would prohibit some individuals from attending the entire series. Keynote

speakers for each session were contacted by mail and then by telephone during the summer of 1988 and a tentative schedule of workshops was arranged. Speakers were chosen because of their expertise in specific topic areas and because of their national reputations for delivering exciting, meaningful presentations to teachers. It should be noted that four of the five speakers identified in the original project proposal were able to speak and a very acceptable substitute was found for the fifth.

Rather than a strict lecture format, speakers were asked to devote part of each session to hands-on or small group work. Project staff assisted the speakers in running the sessions, particularly the individual and small group phases. A limited description of each session will be provided here. Additional information on each session can be found in the workshop series brochure (Appendix B).

Facilities and Scheduling. All workshops took place at a private conference center in Bloomington, Indiana. Our original intent was to have the workshops on the Indiana University campus but no facilities could be scheduled where both food and parking were available. The private center, while somewhat more expensive, was able to provide the needed meeting rooms, meals, and adequate parking. Four of the workshops were scheduled for late afternoon/evening times (4:00 to 8:30 or 9:00) and two were scheduled during the school day. The daytime sessions were repeated twice, once in the morning (8:00 to 11:30) and once in the afternoon (1:00 to 4:30) because there were not enough substitutes in the Monroe county area to have all participants come at the same time. Meals were provided with project funds for teachers at the evening workshops. A snack was provided during the daytime sessions. Teachers were not paid for the time they attended.

Description of the Workshops. The content of the six workshops was selected by project staff to represent a selection of topics on which teachers have looked for the most guidance in recent years. Speakers were contracted to make a presentation on a specific topic although they were given latitude to define the topic as they wished. Additional detail on the workshops can be found in the workshop series brochure (Appendix B).

1. *Integrating Problem Solving in the Mathematics Curriculum*
   Randall Charles, Professor of Mathematics, San Jose State University, California
   September 19, 1988 (late afternoon/evening session)
   Dr. Charles spoke, as the title of the session implies, on including problem solving as part of the day-to-day curriculum of the elementary school. Topics addressed included: What is "mathematical problem solving," "How can the mathematics curriculum be truly organized around problem solving," "How can problem-solving progress be evaluated," and "How can the curriculum be organized so that problem solving is the major focus."

2. *Managing Cooperative Learning*
   Jane Martin, Professional Development Specialist, St. Louis, Missouri
   October 25, 1988 (daytime sessions)
   Ms. Martin focused on using cooperative learning techniques in elementary school mathematics. She included discussion on how and when to group students and on the reasons for grouping students. The notion of "communicating mathematically" was stressed along with expectations for behavior of students working in groups. Much of what Ms. Martin said was a direct follow-up to teaching problem solving as described by Dr. Charles.

3. *Using Manipulative Materials*
   Maggie Holler, Vice President of Cuisenaire Company, New Rochelle, NY
   January 30, 1989 (late afternoon/evening session for primary grades)
   January 31, 1989 (late afternoon/evening session for intermediate grades)
   Ms. Holler presented sessions on using manipulative materials. At her request, one session was presented for primary-grade teachers and a second was presented for intermediate-grade teachers. Manipulatives used at each session were two-color counters, tangrams, attribute shapes, and pattern blocks. Ms. Holler waived her speaking fee so that the money could be spent on manipulatives for teachers who attended. Thus, each teacher received a set of two-color counters and a set of tangrams. In addition, each school that sent teachers to the workshops received one or more sets of attribute shapes and pattern blocks.

4. *Teaching Basic Skills to Children with Special Needs*
   Carol Thornton, Professor of Mathematics, Illinois State University
   March 1, 1989 (late afternoon/evening session)
   Dr. Thornton's presentation focused on techniques for teaching mathematical skills to average and below-average students. Her presentation focused most at the primary level with emphasis on teaching counting skills and basic facts. While the focus was primary, many of the techniques Dr. Thornton suggested were aimed at developing understanding and critical-thinking skills and thus were applicable to all grades.

5. *Developing Estimation and Mental Arithmetic Skills*
   Dale Seymour, President, Dale Seymour Publications, Palo Alto, California
   March 23, 1989 (daytime sessions)
   Mr. Seymour spoke about the importance of teaching estimation and mental arithmetic as

components of "number sense". Mr. Seymour worked on the committee that developed the *Curriculum and Evaluation Standards for School Mathematics* for the National Council of Teachers of Mathematics and thus was able to relate reasons why number sense was a major focus of the *Standards*. In addition to presenting rationale for teaching estimation and mental computation, Mr. Seymour had participants do estimations themselves and then presented a variety of estimation techniques that could be used in the elementary school classroom.

6. *Mathematics for the 21st Century: A Summary.*
   All project staff, Indiana University, Bloomington
   April 20, 1989 (late afternoon/evening session)
   Project staff organized the final session with two purposes in mind. The first was to summarize and integrate the five sessions presented by outside speakers. The second was to address "hard to teach" mathematics topics identified by the participants through a questionnaire at the March 23 workshop. The session began with an overview of NCTM's *Curriculum and Evaluation Standards for School Mathematics*. The overview included discussion of how each of the topics presented by previous speakers fit into the overall goals outlined in the *Standards*. The next part of the session was devoted to small group discussion of the hard to teach topics in elementary school mathematics. Background materials for teaching each topic were collected and disseminated by project staff, and teachers from Dyer elementary school led each of the small groups. The session concluded with discussions of how to get additional information for teaching using the techniques presented throughout the workshop series.

Participants

The participant selection process was as follows. Each of the 14 elementary schools in MCCSC was invited to send a team consisting of the principal and two interested teachers (42 people). In addition, all teachers and the principal (25 people) from Dyer, an MCCSC elementary school, were invited. The private schools in the Monroe county area were invited to send 10 teachers in all, while elementary schools from the school corporations surrounding MCCSC were invited to send a total of 16 teachers and principals. A waiting list was formed so that if some schools did not fill their quota, additional teachers from schools that had already filled their quota were allowed to attend. Participants were asked to make a commitment to attending all six keynote sessions and many of them were able to do so. A few participants attended only one to three sessions while many attended four or five. When space was available for individual sessions, graduate students from Indiana University were also invited to attend.

At one time or another in the workshops, 89 teachers and 6 principals from 22 different

schools (representing 5 school corporations and 3 private schools) were represented. Only two of the individuals who attended taught kindergarten. There were several special education teachers, while the balance of those attending were evenly distributed across grades 1 through 6. The categories of schools represented are shown in the following table.

Schools	# of Teachers	# of Principals
Dyer elementary (MCCSC)	24	1
Other MCCSC schools	40	3
Non-MCCSC Public Schools	18	1
Private Schools	5	1

It should be noted that all private schools in the area were contacted by mail and telephone to encourage attendance of their teachers and principals. The small number of private school teachers in attendance was probably due to the small number of private schools in the area.

Timeline

While the project timeline is not crucial for judging the effectiveness of the project, it does provide useful information for individuals wishing to implement a similar inservice workshop series. For this reason, we have delineated the major project activities and the individuals who completed those tasks.

July 15 to August 15, 1988

Initial contacts made with speakers (project staff: director, principal investigators, graduate assistant, secretarial help)

Preparation of initial brochure on project for teachers and principals (project staff)

August 16 to September 15, 1988

Alternative speaker identified for one keynote speaker who was not able to present (project staff)

Determination of exact dates and confirmation of final plans for keynote sessions (project staff in cooperation with MCCSC administrators)

Confirmation of dates with keynote speakers (project staff)

Identification of teachers to be part of teacher-principal teams from each school (project staff in cooperation with MCCSC principals)

Preparation of final draft of project brochure (see Appendix B, project staff)

Brochures sent to private schools and to schools surrounding the MCCSC area, individuals from those schools identified for participation in keynote sessions (project staff)

Final arrangements completed for meeting rooms, catering of meals, etc. for keynote sessions (project staff)

September 16 to December 31, 1988

First two keynote sessions (speakers and project staff)

Individual and small-group follow-up with Dyer teachers (project staff)

Identification of external evaluator (project staff)

January 1 to April 15, 1989

Three additional keynote sessions (speakers and project staff)

Continued individual and small-group follow-up with Dyer teachers (project staff)

April 16 to May 31, 1989

Final keynote session (project staff)

Collection of written evaluation data from participants (project staff)

Collection of interview data from principals and from Dyer teachers (project staff and outside evaluator)

Continued individual and small-group follow-up with Dyer teachers (project staff)

Initial draft of final project report completed (project staff and outside evaluator)

June 1 to July 30,1989

Second draft of final project report (project staff and outside evaluator)

Preparation of one-page summary of project (project staff)

Mail one-page summary to all school corporations in Indiana (project staff)

State funding for project ends as of July 30, 1989

August 1 to September 30, 1989

Completion of final project report (project staff and outside evaluator)

Distribute copies of final report on request (project staff)

Project Evaluation

The project was evaluated through reactions of both participants and their principals. At the end of each session, those in attendance were asked to complete a short rating form designed by project staff (see Appendix C). Dr. Jill Shedd, an evaluation specialist from Indiana University-Purdue University at Indianapolis, was hired as an external evaluator for the project. In collaboration with project staff, she designed two separate evaluation forms for the entire

workshop series and an interview schedule for principals of the participating teachers. It was originally expected that achievement data from Dyer elementary school would be available as a partial test of the effectiveness of the workshop for those teachers. Those data are not yet complete. Furthermore, given the difficulty of attributing change at Dyer directly to Dyer teacher participation in this workshop series, it was decided that Dyer achievement data would not be included in the evaluation. Dyer teachers were asked to complete a written evaluation of the combined effects of the workshop series and the NSF program operating at their school. Comments from those evaluations and from interviews with selected Dyer teachers have been included in this report.

Procedure

In an effort to evaluate how well this project met its stated objectives, written evaluations and personal interviews were conducted. The final summative written evaluation form for participants was designed with two versions in order to collect data on a range of questions while at the same time keeping the evaluation brief enough to encourage the project participants to answer each question more fully (see Appendix C). Each version was limited to five questions with additional space provided for added comments. The questions, prepared by Dr. Jill D. Shedd (project evaluator), in conjunction with Dr. Peter Kloosterman (project director), addressed the stated objectives of the project. These evaluations were distributed to participants at the last workshop (April 20, 1989) in a random manner so that approximately half of those in attendance completed Form A of the final written evaluation while the other half completed Form B. In addition to the written evaluation, telephone interviews were conducted with 12 of the 14 principals who sent two or more teachers to the workshop series. It is important to note that several of the principals did attended the workshops themselves. The questions posed to each principal were directed toward learning how well the project met its objectives, as well as ascertaining the administrator's perspectives on the changes in teaching behavior resulting from teachers' participation in the project.

Results

A total of 55 summative final evaluations were completed. The distribution of the respondents' teaching level and/or professional position was as follows:

Position	Number	% of Total
Teacher K-3	30	54%
Teacher 4-6	18	33%
Principal	5	9%
Other	2	4%

As to the participants' level of attendance at the six workshops, their self-reported attendance was as follows:

Number of Workshops	Number	% of Total
5 - 6	39	71%
3 - 4	9	16%
1 - 2	5	9%
No Response	2	4%

As the tables above indicate, the vast majority of those who responded to the evaluation were classroom teachers (87% of respondents). Of this group, the majority (54%) taught at the primary level, K-3. Attendance of those responding was very good with 71% participating in either five or all six of the workshops. Consequently, most evaluations were completed by individuals who participated in most if not all of the workshop series.

Analysis of Written Evaluations. All 55 respondents were asked to summarize what they perceived to be the theme/emphasis of the project. Participants wrote that the main theme of the project was to address effective ways to teach mathematics. Most often noted as one emphasis was the importance/value of making mathematics more meaningful and fun for students. Participants wrote that presenting practical, useable applications of mathematics was stressed in the workshops. The rest of the themes cited by respondents referred to specific teaching strategies that they perceived as emphases of the workshops. The strategies referred to most often were the use of manipulatives, hands-on activities, the use of thinking skills, problem-solving, verbalization of thinking, and use of cooperative approaches to learning among students.

Overall, participants' verbalizations of the main project themes suggest that they left the workshop series with a sensitivity to the value and importance of teaching mathematics differently, both in the objectives of their teaching and in the specific strategies and tools used in teaching. The participants' answers suggest that they left with a greater appreciation of the need for focusing on students' understanding of the mathematical concepts behind computation rather than simply on computation. Furthermore, the written responses implied that the participants recognized the importance of teaching mathematics so that it is meaningful for students. Participants reported they gained from the project an appreciation and enthusiasm for the use of more varied ways in which to teach mathematics, including the use of manipulatives, problem solving, cooperative learning, and students' verbalization of their understanding.

The remaining four questions on the two written evaluation forms differed. One version of the form was designed to assess the format of the workshop series, in particular the effectiveness of employing outside experts in the field of mathematics education to present individual workshops. The second version of the evaluation addressed the impact of project participation on the teachers' own teaching and on the teaching of their colleagues (see Appendix C).

First, with respect to the format of the workshop series, participants were asked (on Form A) to comment on the best features of the series, the advantages and disadvantages of the format, and the use of national speakers. Finally, they were asked to describe the "ideal" mathematics

workshop. The positive feature of the workshops noted most frequently was the manipulative/hands-on format of some of the sessions. Also noted were the concrete, immediately applicable ideas and materials which were provided. The quality of the speakers and of their references to recent research was next in frequency of participants' comments. Some individuals reported that the enthusiasm and confidence gained to try the new teaching approaches discussed was the best feature. Finally, some participants pointed to individual workshop topics as the best feature of the workshop series.

In describing the advantages and disadvantages of the series format, a wide variety of comments were written. Noted most frequently was that the evening programs were too long. The remaining comments were contradictory. Several suggested shortening the evening programs by eliminating the dinner, though one person liked the dinner and the informal discussions which ensued. Several felt the day workshops were great, although just as many preferred the evening sessions. Some participants commented that they liked the variety of day and evening workshops and enjoyed having the series offered throughout the year.

Specific to the question about the use of national speakers, the majority of participants wrote that these workshops were better than what they would have expected from local speakers. Yet a few did write that they liked the local presenters better. A couple of participants stated that having both national and local speakers was enjoyable. Note that responses to this question are hard to interpret because "local" speakers was never clearly defined. The final workshop was presented by staff of the Mathematics Education Development Center who, while certainly local, had a different perspective than some other locally available speakers.

In describing the "ideal" mathematics workshop, the major theme underlying the individual comments was that "ideal" workshops include hands-on activities and materials and information to take back to the classroom. For example, several participants suggested a workshop on how to set up a mathematics classroom/laboratory. Others suggested hands-on types of workshops with examples of ideas for inexpensive activities that could be used in the classroom. Another recommended a summative type of workshop for administrators.

The second version of the written evaluation (Form B) addressed the impact of the project on teaching. Specifically, the participants were asked to describe changes they had made or planned to make in their mathematics teaching, to describe what encouraged them to make the changes and what information they had shared with their colleagues. Finally, they were asked to provide any additional comments.

With respect to changes in their teaching of mathematics, participants frequently noted change in the use and/or planned use of manipulatives. Participants also wrote that they were/would be using more problem-solving and cooperative learning in their teaching. Specific changes participants had already made included having students explain their work verbally, using

more concrete examples in explanations, using fewer paper and pencil activities, giving credit for demonstrating how to solve problems rather than only for right answers, and conducting a math fair.

Participants wrote that they were encouraged to make these changes by seeing them demonstrated, either in the workshop activities or in the videos shown during the workshops. Several noted that it was the students' success with and enthusiasm for new methods they had used that stimulated their changes in mathematics teaching. Yet another group of participants noted that the dynamic presentations by the speakers motivated them to change. One participant noted his/her principal's support and encouragement. Another wrote that the textbook used was boring and poor, and the teaching techniques provided in the workshops were good, challenging alternatives. Yet another group stated that the workshops made sense, "it seemed reasonable and logical" to make changes in teaching mathematics.

As to the information that participants had shared or planned to share with their colleagues, the respondents wrote most often that they had encouraged or would encourage others to attend future workshops. Several noted specific information they had shared, for example, the use of manipulatives, the importance of problem-solving strategies, and the use of cooperative groups. Some had shared specific materials with others. It is interesting to note that participants had shared information mostly with friends and/or interested colleagues rather than uniformly sharing information with all teachers in their buildings.

The additional comments that participants provided were quite varied. Several commented on the quality of the workshops and their excitement over the potential of more workshops. Others shared suggestions for different workshop topics and formats.

Analysis of Interviews With Principals. Principals of the participants were asked, during telephone interviews, to provide an assessment of the project from their perspective (See Appendix C). As previously noted, six of the twelve interviewed principals had attended one or more of the workshops. The other six were interviewed to see how much change they had noted in the participants' teaching. While it is possible that teachers had changed in ways that principals were unaware of, it was assumed any change a principal could document would indicate the project was effective.

All principals were asked what they believed the major themes/features of the project were, based upon their own personal attendance at workshops or upon reports from participating teachers. As to the perceived value and results of the project, the principals were asked whether they encouraged teachers to attend, what they felt participating teachers gained from the project, and what evidence they had that the project had affected non-participants teaching in their schools. Finally, they were asked to describe their impression of the "ideal" mathematics inservice for teachers.

When answering the major themes question, principals noted several major themes and features of the project, although no one point was stated more than others. Principals cited emphases on the practical aspects of mathematics, the use of manipulatives, and the use of problem solving. Additional individual comments were made, all of which touched upon the themes noted in the participant evaluations. Two principals couldn't remember the project's focus.

Most of the principals had encouraged their teachers to attend the workshops using a variety of approaches. Several spoke with teachers directly about the series. Other methods of encouragement included morning announcements, flyers, and discussions at teachers' meetings.

All but two of the principals had specific examples of what they felt teachers had gained from participating in the project. Several noted that teachers were using more manipulatives. An excitement about teaching mathematics among the teachers who had participated was mentioned. Individual principals commented on changes they saw in participating teachers' classrooms. For example, some teachers spent more time out of their seats working with children, some were using collaborative learning and grouping techniques, and many were moving away from heavy emphasis on paper and pencil activities.

As to the impact of the project on nonparticipating teachers, the principals noted most often that participants were sharing what they had learned with colleagues in the teachers' lounge and individually. Several principals noted that teachers had ordered more materials for mathematics. Several principals shared specific examples of changes in their own buildings which they attributed to teachers having attended the workshop series and having shared the information learned with colleagues. For example, one principal commented that he had observed greater use of manipulatives and patterning activities in several classrooms. Another principal noted that there was an increased interest in teaching mathematics among all teachers. Yet another principal said that a workshop-attending teacher had planned instructional meetings for other teachers.

The principals who were interviewed believed that the "ideal" inservice program for teachers was a practical workshop with a focus on how to do or apply specific teaching strategies. Another feature of the "ideal" inservice cited was the opportunity to try out the strategies or activities discussed, or the opportunity to observe the use of these strategies. Several principals also commented that the "ideal" inservice would address all grade levels, pointing out the value of specific teaching strategies across grade levels. Principals' comments about the format of an "ideal" inservice were inconsistent. One felt after school programs were best. Another thought summer programs would be best. Workshops during the day once in a while were fine from another principal's perspective.

Evaluation Summary

As a result of participating in this project, most teachers have recognized that there is a need to change the way in which they teach mathematics. Not only did they learn that their teaching

needed to change, but, more importantly, their comments suggest that they learned specific *ways* to change their teaching. Participants' reflections on the main themes of the project indicate that they learned that mathematics needs to be made more meaningful for students and that there need to be more demonstrations of practical applications of mathematics. There is a need to utilize a greater variety of teaching strategies to actively involve students in learning and understanding mathematical concepts and processes. The participants noted that the presentations suggested accomplishing such aims through a variety of techniques: problem-solving strategies, thinking skills, verbalization of thinking, manipulatives, and cooperative learning. Furthermore, in describing changes they had made or planned to make in their teaching of mathematics, it is apparent that the participants were integrating the techniques they had learned into their classroom teaching. Consequently, it appears that the project met successfully the first five of its stated objectives for teacher participants. (See the Objectives section of this report for a complete list of project objectives.)

It is less clear that the objectives relating to teaching computational skills and teaching estimation and mental computation more efficiently were met. Regarding computational skills, individual participants did note that they had begun to focus more on students' methods for computations (i.e., having students explain their work or giving credit for demonstrating their computations) in contrast to giving credit only for right answers. Yet, this point was not made by a large number of participants. Similarly, few participants wrote specifically about estimation and mental computation. Although it appears that some participants have changed their emphasis on teaching of computational skills, estimation, and mental computation, these specific topics were mentioned less frequently than other teaching strategies cited in the objectives of the project.

With respect to the project's objectives related to administrator participants, the interviews with the principals suggest that they understood the main themes of the project and thus recognized the necessity of change in mathematical instruction. Their summaries of the theme were consistent with those written by the teacher participants. The interviews did not specifically address whether principals would support changes in teachers' efforts to teach mathematics. Many comments made by the principals do indicate, however, that most will support those teachers wanting to change their mathematics teaching. For example, the majority of principals actively encouraged their teachers to attend the workshop series. Six of the principals attended at least three workshops with three of those attending five or six. Also, *all* changes observed in participants' teaching of mathematics by principals were positive.

Advice to Others Planning Inservice in Mathematics

An objective of this project was to provide data on the effectiveness of the "six workshop" model for inservice in Indiana. Evaluation data indicate that such a model, when applied as it was for this project, is effective. The written evaluations suggest that teachers were responsive to the

project's theme that the teaching of mathematics needs to include greater focus on understanding of mathematical concepts and on teaching mathematics as a meaningful and practical subject. As to specific teaching techniques, the participants seemed to appreciate learning about the use of manipulatives, problem solving, thinking skills, and cooperative learning.

In addition to the theme and topics for an inservice program outlined in this report, specific suggestions about to the content and format of workshops can be drawn from the project evaluation. Teachers appeared to be most appreciative of presentations that included practical information, hands-on activities, and materials that could be taken back to their classroom. As to the type of presenters a program might include, it is unclear whether involving "national" experts is important. Although the participants clearly enjoyed each of the national presenters, the evaluations suggest that the participants enjoyed and benefited from specific qualities of the speakers and their presentations rather than simply the fact that they were national experts. The participants appreciated a *dynamic* speaker, one who incorporated recent research in his/her presentation and one who spoke from a practical perspective. The evaluation data suggest that these qualities, qualities which are not necessarily exclusive to "national experts," were important to a presentation being informative and well-received.

Data from the project evaluation suggest that many participants actually made changes in their mathematics teaching and/or are planning changes. What encouraged participants to change and thus what are the keys to effective inservice? It appears that the *quality* of the speakers and of the workshop series in general was very important. "Seeing it done" -- watching videos of classrooms, participating in activities in the workshop, discussing teaching strategies that worked for other teachers -- was noted most often by participants. The speakers effectively presented issues and teaching strategies. As one participant wrote, "for the first time it (change) really seemed reasonable and logical . . . ." Ultimately, several participants wrote that it was their students' enthusiasm for the new techniques they tried in their classrooms that convinced them the techniques were as powerful as the speakers had suggested.

Budget Summary

The total budget for the project was $30,209. Exact expenditures in budget categories will be sent to the Indiana Department of Education by the Indiana University office of grants and contracts when bills for all encumbered funds have been paid. Because this document is intended both as a final report and as a guide to school corporations interested in knowing how to budget for similar workshops, the table below lists the budget by categories. Final expenses should be very close to these figures. It should also be noted that a considerable amount of donated time was put into the project by staff of the Mathematics Education Development Center. Without this time donation, personnel costs would have been considerably higher.

Budget Category	Amount
Personnel (project director and investigators)	$2250
External Evaluator	1000
Graduate Assistant	6000
Clerical Help	600
Fringe Benefits	282
Consultants (outside speakers)	2700
Travel (expenses for outside speakers)	1525
Printing (project brochure and final report)	991
Substitute Teachers (to cover participants during daytime workshops)	2534
Meals and Room Costs for Workshops	4740
Materials and Supplies (handouts, manipulatives, office supplies)	5350
Total Direct Costs	**27,972**
Indirect Costs (8% of direct costs)	2237
Total Costs	**$30,209**

APPENDIX A:

Description of the National Science Foundation Sponsored Project Currently Under Way at the Mathematics Education Development Center

Description of the National Science Foundation Sponsored Project Preparing Teachers to Teach Mathematics: A Problem-solving Focus

A Project of the Mathematics Education Development Center
Indiana University
Bloomington, Indiana

Project Director: John F. LeBlanc
Co-Principal Investigators: John F. LeBlanc & Frank K. Lester, Jr.

Preparing Teachers to Teach Mathematics is a 3-year project recently begun at Indiana University as a response to the growing concern in the United States about the quality of teacher education. More specifically, the Project focuses on the preparation of teachers to teach mathematics in the elementary school and has four principal goals:

I. To develop new mathematics courses to be taken by all prospective elementary school teachers. One course will consolidate work in foundations of real numbers and geometry; another will consider topics in finite mathematics.

II. To develop a course on mathematical problem solving. This course will focus on methodology appropriate for enhancing problem-solving skills in both teachers and elementary school children.

III. To work with experienced teachers to help them broaden their views of the nature of mathematics and to assist them in developing teaching techniques for improving mathematical thinking skills and problem-solving ability.

IV. To create a model for disseminating the concept and materials developed by the Project across the state-wide Indiana University system.

The Project is sponsored by a grant from the National Science Foundation and involves collaboration among three groups: Mathematics Education faculty at Indiana University, the Mathematics Department at IU, and the Monroe County Community Schools Corporation.

APPENDIX B:

Workshop Series Brochure

Mathematics for the 21st Century: Preparing Elementary Teachers

A Series of Six Inservice Workshops for the Monroe County Area

Using federal Title II funds, the Indiana Department of Education has funded a series of six inservice workshops focusing on key issues in the teaching of mathematics at the elementary school level. Each workshop will feature a nationally known speaker who will inform participants about promising and innovative practices and provide the examples and materials necessary to allow these innovations to be put into immediate classroom use. The last hour of each session will be devoted to discussion of how teachers might share ideas from the sessions with other faculty. The workshops are organized by the Mathematics Education Development Center at Indiana University. Staff from the Development Center will aid speakers in a "hands-on" segment for each session.

The workshop series is designed for elementary school teachers and principals. Each elementary school in the Monroe county school system will be invited to send the principal and two teachers. Additional spaces have been reserved for private school personnel and for a limited number of teachers and principals from schools outside of Monroe county. It is expected that participants in the workshop series will share ideas gained from the sessions with other staff in their schools.

Four of the workshops will be scheduled for evening times (4:00 to 8:30) and two will be scheduled during the school day (8:00-11:30 *or* 1:00 to 4:30) Dinner will be provided at the evening sessions. Substitutes will be provided for teachers who attend the two sessions which take place during the school day. *The workshops have been organized with the expectation that participants will attend all six sessions.* MCCSC teachers who attend will receive four hours of fall 1988 PIVOT credit and three hours of spring 1989 PIVOT credit .

Topics and Speakers

Monday, Sept. 19, 1988. 4:00-9:00 p.m.(dinner included) at Terry's, Westbury Village (intersection of St. Rds. 37 & 46). Randy Charles, professor of mathematics education at San Jose State University will speak on **Integrating Problem Solving in the Mathematics Curriculum.** Issues addressed will include topics such as: What is mathematical problem solving all about? How can the curriculum be organized around problem solving? How can I teach problem solving in first grade? Can problem solving be taught before students have mastered computational skills?

October 25, 1988. Choose 8-11:30 am or 1-4:30 pm at Terry's, Westbury Village. Jane Martin, inservice specialist from St. Louis, will speak on **Managing Cooperative Learning.** Getting students to work cooperatively is an excellent mechanism for helping them learn to communicate mathematically. Ms. Martin will discuss discipline techniques and organizational strategies useful for promoting high mathematical achievement.

January 30, 1989 (K-3) and January 31, 1989 (4-6). 4-8:30 p.m. (dinner included) at Terry's, Westbury Village. Maggie Holler of Cuisenaire, Inc. will speak on **Teaching Mathematics with Manipulative Materials.** Issues addressed will include: How can manipulatives be used to increased understanding of mathematical concepts? Are manipulatives compatible with my textbook? Are manipulatives more important for certain types of students? Are there content areas for which manipulatives are not important?

March 1, 1989. 4-8:30 p.m. (dinner included) at Terry's, Westbury Village. Carol Thornton, professor of mathematics education at Illinois State University, will speak on **Teaching Basic Skills to Children with Special Needs.** While her talk will include techniques that are appropriate for all students, it will focus most heavily on methods of improving skill development for children who are experiencing difficulty in mathematics.

March 23, 1989. Choose 8-11:30 am or 1-4:30 pm at Terry's, Westbury Village. Dale Seymour, president of Dale Seymour Publications, will speak on **Developing Estimation and Mental Arithmetic Skills.** Given the availability of calculators and computers, students need to know when to use these tools and how to estimate answers to make sure a calculator has been used correctly. Mr. Seymour will discuss the importance of these issues along with how they apply to instruction in the elementary school.

April 20, 1989. 4-8:30 p.m. (dinner included) at Terry's, Westbury Village. Staff of the Mathematics Education Development Center at Indiana University will present **Mathematics for the 21st Century: A Summary.** (3 MCCSC Pivot credits available.) This final session willsummarize and tie together the topics addressed by the previous keynote speakers. There will be opportunities for participants to share their experiences in trying to implement speakers' suggestions and to ask about topics that were not covered in the keynote sessions.

Who To Contact

MCCSC teachers who are interested in participating should contact their principals.

Personnel from private schools and from schools outside of MCCSC can apply by contacting the Mathematics Education Development Center by phone (855-0860) or by mail (Indiana University, Education 309, Bloomington, IN 47405).

Individuals wishing additional information may contact Dr. Peter Kloosterman or Dr. Diana L. Kroll at 855-0860.

APPENDIX C:

Evaluation Instruments

Sample of Evaluation Form Used at the End of Each Session

Please respond to the following. Place evaluations in the box by the door when you leave.

Please indicate: Teacher _____ Principal _____

1. The topic covered in the session was:

1 2 3 4 5
(not important) (important)

2. The overall quality of this session was:

1 2 3 4 5
(low) (high)

3. I feel I will utilize the concepts presented during the session.

1 2 3 4 5
(not at all) (fully)

4. The speaker's knowledge of the session content was:

1 2 3 4 5
(low) (high)

5. The speaker was well prepared.

1 2 3 4 5
(disagree) (agree)

6. The speaker was interesting and enthusiastic.

1 2 3 4 5
(disagree) (agree)

7. The format of the session (4:00-9:00 meeting with dinner) was appropriate.

1 2 3 4 5
(disagree) (agree)

8. Comments (use back side if necessary)

Final Overall Participant Questionnaire - Form A

Please indicate:

___ K-3 teacher ___ 4-6 teacher ___ Principal ___ Other _____(specify)

_____ Number of workshops attended (out of 6)

1. Briefly summarize what you see to be the main theme/emphases of this workshop series.
2. Describe the best features of this workshop series.
3. Describe the advantages/disadvantages of the format of this workshop series (4 evening workshops with dinner, 2 workshops during the school day) as compared with others you have attended.
4. An expensive feature of this workshop series was our attempt to bring in the best possible speakers from across the country. In your opinion, were these workshops better than what you would have expected had "local" speakers been used? Explain.
5. Describe the "ideal" math workshop for you, including topic and format; one that would be most helpful to you.
6. Additional comments

Final Overall Participant Questionnaire - Form B

Please indicate:

___ K-3 teacher ___ 4-6 teacher ___ Principal ___ Other _____(specify)

_____ Number of workshops attended (out of 6)

1. Briefly summarize what you see to be the main theme/emphases of this workshop series.
2. What changes have you made/will you make in your math teaching as a result of attending this series? If NONE, please describe your current teaching approach to math.
3. What encouraged you to make and/or plan these changes?
4. What information have you/will you share with your colleagues about this workshop series?
5. Additional comments.

Telephone Interview Questions for Principals, May 1989

Principal's Name _____

Principal's School _____

Workshops attended by principal (if any)

Names of teachers from principal's school who attended one or more workshops:

Interviewer's Name _____

Interview Date _____ Interview Time _____

Introduction: *Hello, I am _____ from the Mathematics Education Development Center at Indiana University in Bloomington. As you may or may not know, we directed a set of six inservice workshops on mathematics teaching for elementary school teachers during this past school year. The workshop series, titled "Mathematics for the 21st Century," was funded by the Indiana Department of Education. We are currently putting together our final report to the Department of Education and would like you to respond to several questions about the workshops and participation by your teachers in them. This should only take a few minutes. Is this a good time to talk?* (Assuming principal agrees, continue. Otherwise, try to set up another time to call back.)

1. *First of all, I need to know if you are aware of the workshops.* Write any opening comments made by the respondent below. If respondent is not aware of the workshops, mention that 4 of the workshops (September, January, February and April) took place from 4--9p.m. while two (November and March) took place during the school day. All workshops met at Terry's Conference Center in Bloomington and covered topics such as problem solving, cooperative learning, and using manipulatives. If respondent doesn't seem to be aware of workshops, mention names of teachers who attended. Ask if the respondent now remembers the workshops. If not, thank him/her for his/her time and end the interview.

2. *From your experiences at the workshops or from what you heard from your teachers, what do you think were the major themes and features of the workshops?*

3. *Did you encourage your teachers to attend these workshops? Explain.*

4. *What do you feel your teachers have gained from the workshops? Please be as specific as you can. If possible, cite examples of changes in the way teachers who attended are now teaching or comments that teachers made about the workshops.*

5. *Do you have any evidence to indicate that these workshops affected teachers other than those who attended? For example, did teachers share ideas from the workshops with other teachers or did they talk to you about getting mathematics materials?*

6. *Please describe what you see as the "ideal" mathematics inservice for teachers.*

Thank you for your time. As a closing note, let me say that we have applied for State funding to continue and expand the workshops for next year. If that funding is approved, you will receive information on the new workshops when school starts in the fall. We welcome continued participation by you and your teachers.